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THE PRUNING OF THE VINE.

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ACKNOWLEDGMENT.

THE subject-matter of this bulletin first appeared in the form of a series of articles in the *Agricultural Gazette* of New South Wales, begun while Mr. Laffer was Viticultural Expert of the Department. Subsequent to his retirement from the service, Mr. Laffer generously completed the articles, thereby making available to the Department and to the viticulturists of the State, his valuable experience.

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The Pruning of the Vine.

PRUNING at the present day may be said to have been reduced to an art which entails certain manipulations of the growth of a plant with a view to securing an unnatural result in the development of the fruit and vegetative portions.

In a state of nature, the amount of growth and fruit produced is determined by climatic factors which regulate the amount of food supplied. This food is distributed over the full complement of buds, and when therefore the number of buds is large, there is insufficient energy to develop both wood and fruit to perfection. We find that trees and plants which are permitted to grow freely in their natural habit, become weaker as the years go by while their fruit becomes very small, woody in texture, and of little commercial value. The young wood is produced at the extremities of the branches and the lower portions of the old wood have a tendency to become bare and fruitless. By skilled pruning the number of buds is so limited that the individual growths may be vigorous. This implies that there will be ample energy in the vine to bring the fruit to commercial perfection, in addition to assuring suitable wood for the following year. In this way, not only is the crop assured for the time being, but provision is made from year to year *for the general renewal of growth and maintenance of vigour.*

Underlying all systems of pruning are certain principles which have their origin in a study of the laws which govern the growth and fruit-bearing characters of plants. As they vary in every species of plant, and even amongst individuals of the same species, a clear understanding of these principles will facilitate operations.

These laws may be summarised as below, and each will be found to be applicable in some measure to the pruning of all classes of plants.

1. "The vigour of growth of a plant or shoot, all things being equal, is in direct ratio to the number of its leaves." It will always be noted that a vigorous plant has an abundance of foliage during the growing season. The leaves act in the atmosphere in much the same manner as the roots do in the soil.

2. "The nearer a shoot approaches a vertical position the greater its vigour of vegetation."

3. "The vigour of a shoot, or portion of it, diminishes the nearer it approaches to a horizontal position." The two latter principles have special application to vines or trees trained upon trellis. Growths which are more *or less vertical have a tendency to overpower those which are less advantageously placed.*

4. "Deformations of any kind, such as those induced by wounds or compressions, reduce the vigour and activity of plants or those portions affected by them." This is illustrated by accidental ligatures or abnormal wounds or injuries.

5. "The smaller the number of buds upon a shoot or plant, the greater the vigour of each individual shoot growing from them." A vine spur of two buds develops stronger canes than a rod with a greater number upon it. This is a very important rule in pruning. It does not necessarily follow that a plant with but a limited number of shoots is strong, though the individual shoots are so.

6. "When a series of shoots of a healthy plant are placed on different levels, all things being equal, it is usually the topmost one which becomes the strongest." A casual examination of plants in general will serve to demonstrate this fact.

7. "When a portion of a vertical shoot is bent sharply at an angle, buds situated close below the bend will give rise to very strong shoots, while those beyond will suffer in proportion." A vine cane bent sharply and tied down to a wire will throw strong growths below the bend.

8. "*In any plant or individual shoot of a plant, the number of flowers* is in inverse ratio to its strength." That is to say, plants in a condition of excessive vigour have the tendency to produce but little fruit.

9. "The production of fruit is weakening to a plant for the reason that it draws the food away from the wood and stores it in the fruit, which is simply a means of reproduction." Thus we find that overproduction of fruit is weakening to the annual growth.

10. "The smaller the number of fruits, the greater their individual size." This must, of course, apply only within certain limits.

11. "The development of the fruits is inversely proportionate to the size of the shoot which bears them." This also has its limitations, for whereas very strong shoots fail to carry fruits of finest quality, on the other hand, too weak a shoot is incapable of nourishing it. Good average growth is the best fruit producer. The vine is a plant which remains productive over a long period, and pruning with a due regard to the application of these rules will serve to the maintenance of health, vigour and fruit-bearing over the greatest number of years.

Pruning involves something more than the indiscriminate removal of certain portions of the growth annually. In its highest sense, it should imply a knowledge of the functions of each portion of the vine, and such treatment of them as secures the desired result with a minimum of injury to the vine generally.

The skilled pruner takes in at a glance the whole structure of the vine, and quickly decides the course of treatment. He understands the habits of growth and fruit-bearing peculiar to the variety of vine he may be pruning, and manipulates its wood in such a manner as to ensure the balance between wood and fruit production. Definite systems of training vines have been evolved by the experience of generations, and the pruner, understanding the principles involved in each system, should ever have the perfect type in view. Although the attainment of the ideal may be somewhat difficult, it may safely be said that the nearer one can approach the type, the better the ultimate result.

In the interests of efficiency and economy, the pruner should strive to complete the whole operation with a minimum number of cuts, and to this end clean pruning is of great importance. Where a portion of the growth has to be cut away, it is no more difficult, nor does it take any longer, to completely remove the wood in such a way that the base buds will not remain. This is a point which is too frequently neglected, and more often than not, short stubs are left upon the vine, each one carrying several immature base buds. As a result of this practice, one or more growths of a spindly nature develop at these scars in the following season. Therefore the necessity of summer pruning arises, an operation which entails much time and labour, all of which might be saved by a little care in the first instance. Failing proper summer treatment, these growths develop at the expense of the fruiting wood, and moreover, have again to be removed at the following winter pruning. The vines become too dense in their growth, excluding light and encouraging disease; the fruit and the necessary wood are deprived of nourishment, the wood becomes weak in its nature, and if this point is constantly neglected, the whole vine ultimately becomes a dense mass of useless growths. In order to bring it back to a proper state, much work is required and frequently severe cutting is needed, to the detriment of the crop for the time being. The framework of the vine may be looked upon as a structure upon which a definite amount of fruit-bearing wood can be placed. Growths other than those needed for fruit production and renewal of the permanent wood, must be looked upon as an evil which unnecessarily saps the vigour of the general growth.

THE OBJECTS OF PRUNING.

The art of pruning has three primary objects :—

1. To obtain fruit of uniformly good size and quality from year to year.
2. To maintain the vigour of the plant over a long period of years by balancing the production of fruit and wood.
3. To facilitate and economise in the cultural operations by restricting the spread of the trees or vines beyond the necessary limits.

In marketing fruit, size and quality count for everything. The consumer buys very largely through the eye, and therefore the fruit of good size and appearance is the one which sells best. Inferior fruit is difficult of sale even at the best of times.

In developing the maximum quality, good pruning plays a very important part, because it regulates the number of bunches which a vine is able to produce, and assures that, under normal conditions, each bunch will be brought to perfection. The maintenance of vigour is important, not only in so far as it affects the life of the vine, but also by the fact that it is reflected in the development of the fruit. The balancing of the vine, in order that the fruit shall not be secured at the expense of the growth, assures the renewal of the wood from year to year. It is only necessary to neglect the pruning of a vine for one year to see how quickly both wood and fruit deteriorate. One may secure a great number of bunches produced on innumerable weak growths, but they will suffer both in size and quality.

The question of facilitating cultivation is important for the reason that it permits of a greater proportion of the work being accomplished by horse power, thereby reducing the amount of hand-labour needed. Cultivation becomes more economical where the compact nature of the trained vine permits of a freer use of horse-worked implements.

THE STRUCTURE OF THE VINE.

The vine is composed of the stem, main arms, secondary arms and annual shoots. *This structure is illustrated in the accompanying Fig. 1.*

The stem represents the permanent portion of the structure, and is the main channel of sap distribution between the root system and the other portions of the vine; in view of this, every care should be bestowed upon it. It should be trained with care, avoiding twists and deformations so far as possible, and so long as the vine exists, should be protected from injury. From time to time water shoots may be developed upon the stem, and they should be removed in such a manner as to avoid unnecessary exposure of the tissues and ultimate dry scars. Accumulations of dead wood are objectionable in so far that they lead to obstructions of the sap flow, and in addition are a source of trouble by their encouragement of dry rot and white ants.

The main arms are of but little less importance than the stem, and are practically permanent. Besides being the main subsidiary channels of sap flow, they perform the important function of supporting the secondary arms. According to the system of training applied to the vine, the main arms may number from one to three, and in rare cases more; in common with the stem they should receive every care. Where vines are trellised, the mistake is often made of twisting the main arms around the wires. Although this practice is permitted in the training stage, simply in order to secure straight arms, it is not advisable to allow them to remain so for more than one year. It is a simple matter to untwist at the end of the first year, by which time a sufficient degree of rigidity will have been secured to ensure straight lines.

The objection to a permanent twisting is that the wire may eventually strangle the arm, and further that it becomes impossible to remove the wire if so desired.

The number of *secondary arms* is only limited by the strength of the vine. They support the fruit-bearing wood and, although not permanent in the

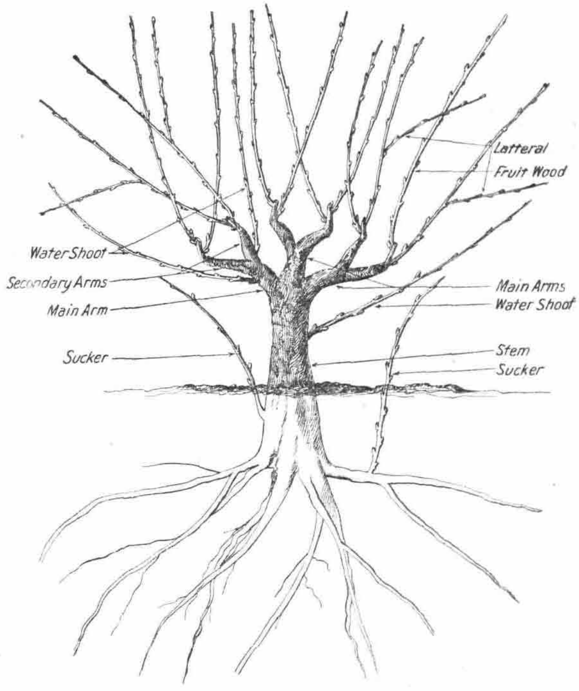

Fig. 1.—Diagrammatic representation of a vine, illustrating its various parts and the several types of annual growth.

same degree as the main arms, they should receive such treatment as will retain freedom of sap flow. Secondary arms tend to become elongated in the course of time, for the reason that each year adds a small portion to their length from the base of the old spur. Careful pruning serves to prevent

undue lengthening, while at the same time the avoidance of unnecessary injury will serve to maintain their vigour by eliminating dead wood. No matter how much care may be taken, it is but a question of time when the arms become unduly long or lose vigour through the accumulated scars checking the flow of sap. One of the objects attainable by systematic pruning is the periodical renewal of these long or worn-out arms.

Annual shoots are the growths put forth from the more permanent structure and, for the purpose of description, may be subdivided into fruit-bearing wood, water shoots, and suckers.

Fruit-bearing canes arise from the previous year's spurs or rods, and as a rule, have behind them two consecutive years' wood. Such canes carry buds which in the following season will develop fresh canes that are fruit-bearing in their nature. This fruit-bearing wood serves to build up the framework of the vine, and therefore, apart from other considerations, it should be maintained in a vigorous condition.

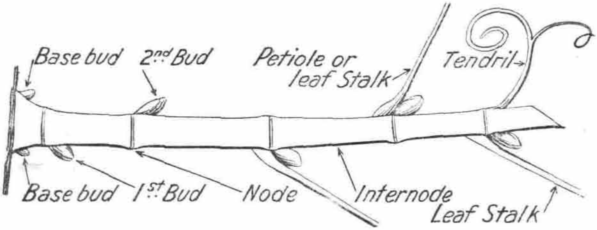

Fig. 2.—Diagrammatic representation of portion of a vine cane, showing external structure.

Water shoots are strong canes developed from some portion of the vine other than the one-year-old wood. They have their origin in latent buds which, failing to break in their normal period, become embodied in the tissues of the older wood. Thus they may arise from any portion of the stem, main or secondary arms. For some reason—such, for instance, as a sudden and excessive sap flow due to rain or irrigation, to some check of the sap in worn-out arms, or by reason of very hard pruning—they break into active growth. Thus, in a sense, they represent safety valves on the vine, affording an outlet for vigour which the normal complement of buds is unable to absorb. In moderate numbers, they indicate a reserve of energy and that the vine is not being taxed to its utmost; in excess, they indicate too hard pruning, or else that portions of the vine require to be renewed. Water shoots have their uses in developing additional secondary arms, and in renewing injured or worn-out ones. They should not be confused with the growths developing from scars where canes have been imperfectly removed in the previous year.

The term " sucker " is applied generally to shoots which arise from a portion of the stem below the soil surface. In the strictest sense, suckers are growths arising directly from the root systems, but in the case of the vine, this rarely occurs. The so-called suckers are more in the nature of water-shoots arising from the stem below the ground. Under general circumstances, they may be said to have no use, but cases do occur when it is possible to renew the old stem by training a sucker to take its place. Unless this is desired, the growth should be removed in such a way that no base buds are left for its renewal in the following season. The simplest and best plan is to uncover the base, and completely split or cut the growth away from the stem.

Strong annual shoots throw out from various points upon their length more or less vigorous growths which are known as "laterals." The normal bud is preserved at their base. In certain of the rod-pruned varieties, they at times have their uses as a means of increased fruit production.

The Vine Cane.

The annual wood of the vine differs somewhat from that of most other commercial fruit-bearing plants. A reference to Fig. 2 will serve to show that it is composed of sections defined by a slight enlargment of the diameter

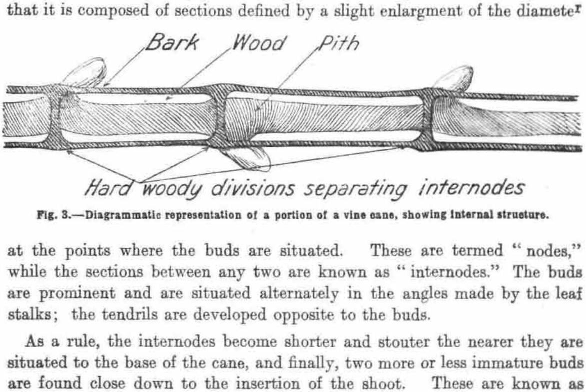

Fig. 3.—Diagrammatic representation of a portion of a vine cane, showing internal structure.

at the points where the buds are situated. These are termed " nodes," while the sections between any two are known as " internodes." The buds are prominent and are situated alternately in the angles made by the leaf stalks; the tendrils are developed opposite to the buds.

As a rule, the internodes become shorter and stouter the nearer they are situated to the base of the cane, and finally, two more or less immature buds are found close down to the insertion of the shoot. These are known as " base buds," and are not, as a rule, taken into account when the vine is being pruned. They serve as an additional outlet for growth should the first and second buds of the spur fail for any reason.

The internal structure of a cane, is illustrated in Fig. 3. It will be observed that it differs from other wood by reason of the large mass of pith constituting the central core. Thus, it will be seen that the cane consists of an outer bark enclosing a section of fibrous woody tissue much in the nature of a tube. The core consists of an accumulation of loose spongy cells, technically known

as "pith." The nature of this pith enables it to absorb and hold a considerable quantity of moisture in the winter season. Further, in the processes which constitute the ripening of the wood, the pith acts as a repository for quantities of those substances which serve as food elements to the plant. This reserve food supply is used during the early spring for the purpose of nourishing young growth in its first stages of development.

Separating each internode from its fellow is a hard woody septum or division which is marked externally by a distinct line around the cane just at the base of the bud. Internally, these divisions cut off the contact of the pith at each node. So far as the reserve food supply is concerned, the communication of each bud is with the internode above and not with that below, as might at first sight be supposed. In wet, cold countries, this hard division is used as a means of preventing decay in the pith with consequent injury to the bud below. The practice under such conditions is to leave a full internode above the top bud, protected on top by the hard, woody

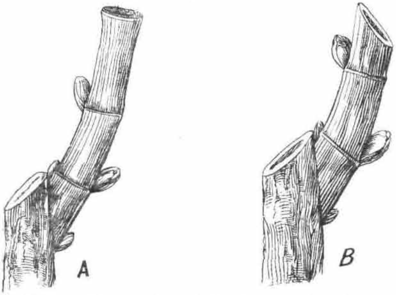

Fig. 4.—Diagrammatic representation of the method of making the vine spur.
A. Internode projecting above the bud. B. Usual method, cut short above second bud.

septum to prevent the entry of water and bacteria which might set up decay. (*See* Fig. 4A.) It is claimed that the usual practice of cutting a short distance above the bud, leads to considerable damage by frost and rain. Conditions in Australia do not as a rule necessitate the observation of this precaution although many vignerons adopt it on physiological grounds. The internode dries up as the season advances, and it has been contended that the presence of the dry portion at the summit entails additional work in its removal at the subsequent pruning. As a matter of fact, this contention does not hold good. The pruner, when re-establishing the spur, will naturally select the lowest suitable fruit cane, and consequently the dead stub falls off with the portion of the old spur severed. There are many arguments for and against this treatment of the spur, but it may be considered to have no special application to Australian conditions. Fig. 4B illustrates the common method of making the section a short distance above the bud.

THE ROD AND THE SPUR.

A spur may be defined as a portion of the annual wood of the vine which has been cut back to a general length of two buds. In some cases three, or even four, buds are left, but such are an exception in the general treatment of the vine.

A rod is a portion of the annual growth which, mainly for purposes of fruit production, is cut back to a length greater than four buds and tied down by its extreme end to a wire or some portion of the vine.

By reason of the limited number of buds constituting a spur, the growth from each under normal conditions is strong, and capable of developing large bunches of fruit, as well as providing wood for re-establishing the spurs in the following year. The spur may thus be said to fill a dual purpose in providing both the fruit and the wood from which the framework of the vine is built up. Consequently, it will be readily understood that in selecting the spurs, all things being equal, the preference should be given to those which will maintain or improve the general contour of the vine. By reason of the limitation of the number of buds on a spur-pruned vine, it can naturally carry a greater number of secondary arms as compared with one which is rod-pruned. In fact, it may be said that the number of secondary arms is limited only by the vigour of the vine.

In the case of rod-pruned vines, the purpose of the rod is purely for fruit production, and therefore its position, in so far as it affects the shape of the vine, need not be considered. The rod is of only a temporary nature, and it is removed at the pruning subsequent to its having borne fruit.

In view of the numerous buds which have to be nourished, the individual growths are generally weak, and are therefore not suited to the purpose of renewing the fruiting wood. Apart from this fact, the canes upon fruiting rods are usually a long way from the permanent wood of the vine. Under these circumstances the use of these canes would lead to a badly constructed framework. In order to overcome this difficulty, the spur is used in conjunction with the rod. The former assures renewal of good strong canes, which may be used for the purpose of re-forming while the rod is carrying the fruit. With this object in view, it follows that the spur must be given preference of position in so far as it influences the shape of the vine. It is preferable to select a well-placed water shoot rather than a badly-placed fruit shoot. The rod, on the other hand, must be a fruit-bearing cane, and the question of its position on the vine does not matter so long as *it yields the fruit. Under* normal conditions of growth the spur and the rod will be created from the two canes upon the previous year's spur, the lower one being made into the new spur, and the upper one the new rod. When the vine is wholly spur pruned, *the spurs should always be fruit-bearing wood.*

There are several reasons for adopting this differential treatment in the annual pruning of the vine. The accumulated results of experience in vine pruning have demonstrated that whereas some varieties yield the best results from spur pruning, others again give more fruit if pruned with one or more rods.

In certain varieties the fruit-bearing wood is produced from practically any healthy bud upon a fruit-bearing cane. In these varieties, the reduction of the canes to short spurs assures a prolific fruiting. An extension of these spurs into rods would, under normal conditions of culture, result in over-production, with a consequent falling off in the quality of the fruit. Such varieties are generally large-bunched, as in the case of table grapes, and where quality is required there is no doubt that this system of pruning gives excellent returns. There are cases wherein the normal size of the bunch is small to medium, and although they will fruit very satisfactorily on the spur system, the maximum weight of fruit possible would be below the normal capabilities of a strong vine. Under conditions which are conducive to vigour, the use of rods in conjunction with spurs assures a much heavier crop. Such conditions are supplied by irrigation on very fertile soil with a good rainfall. The same object can be secured to a great extent by increasing the number of spurs to such an extent as to very materially increase the crop, but unless this can be accomplished without excessive crowding it is better to make use of some rods. On the other hand, when the vines are but normal to weak in their growth, the spur only should be used. This same rule applies in vines which are normally rod-pruned, but may become weakened from some reason or other. As a temporary expedient, the rods should be dispensed with for a year, in order to renew the strength of the canes upon the spurs.

There are other varieties which have a different habit of fruiting, and to which the spur system does not apply satisfactorily. In these cases the fruiting canes are developed from buds at some distance from the base of the cane, usually extending from about the fifth or sixth bud towards the extremity. It follows, then, that if the cane is suppressed to form a spur, there will be practically no crop of fruit. The pruning of these varieties necessitates the use of rods for fruit-production, and in general they range from six up to ten or twelve buds, according to the vigour of the vine.

In all cases the grower should have a knowledge of the habit of fruiting of his vines, and he should adopt the system of pruning to suit the conditions of soil and climate under which he may be working.

If table grapes are the objective, with few exceptions the spur system will prove the best, by reason of the more uniform size and quality of both bunches and berries.

Some of the best known varieties grouped under the spur system of pruning are as follows:—Muscat Hamburgh, Black Hamburgh, Doradillo, Muscat Gordo Blanco, Muscat of Alexandria, Grand Turk, Duke of Buccleugh, Temperano, Trebbiano, Sweet Water (Palomeno), Palomeno Blanco, Lady's Finger, Black Malaga, Red Malaga, Red Prince, Santa Paula, Pedro Ximenes, Gros Colman, Trentham Black, Frontignac, Belas Blanco, Royal Ascot, Ulliade, Whortley Hall, Chasselas, Royal Muscadine.

The exceptions amongst table varieties are:—Waltham Cross, Daria (Ohanez), Sultana Centennial, Raisin des Dames, Cornichon, and Crystal. The above-mentioned varieties appear to yield more consistent crops if pruned with a proportion of rods.

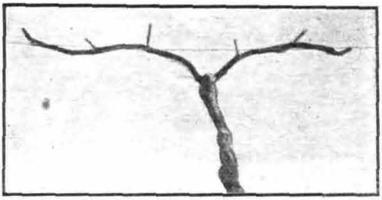

Fig. 5.—A weak growing vine .spur pruned on two short main arms.

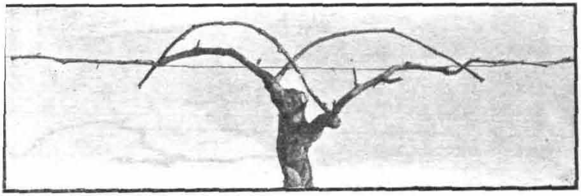

Fig. 6.—A strong vine, rod and spur pruned.

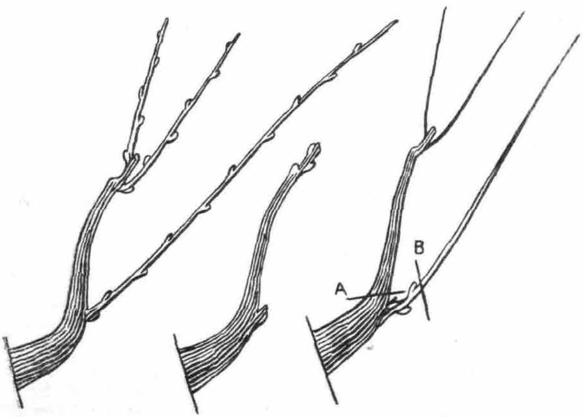

Fig. 7.—Diagramatic representation of a watershoot and its treatment in shortening back a secondary arm.

Amongst the varieties normally devoted to wine-making, Mataro, Grenache, Doradillo, White Hermitage, Pedro, Blanquette, Verdelho (Madeira), and Hunter River Riesling (Semillon), all respond to spur pruning. These vines, however, growing under conditions which develop great vigour, will return much heavier crops when pruned to the rod and spur. The same may be said of most of the spur pruned table varieties when size and quality of the individual bunch are sacrificed for the purpose of securing heavier crops. This can, of course, be safely undertaken where irrigation is possible, or upon soil which is more than ordinarily fertile.

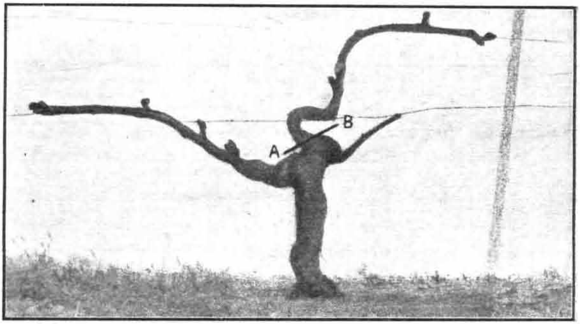

Fig. 8.—A badly constructed arm, and the method of training a water shoot to replace it. Next year the old arm will be cut off at AB

Wine varieties which should always be rod pruned if full crops are to be secured, are the Riesling, Shiraz (Hermitage), Malbeck, Carbernet, and Sercial. One vine, the Zante Currant, may be placed in a class by itself, demanding treatment differing from all other varieties. By nature it is exceedingly vigorous, and in order to curb its rampant growth the vine was for many years heavily loaded with rods. Even then the setting of fruit was most unsatisfactory. Subsequent to the general adoption of the practice of "cincturing," or "ring-barking," the non-setting habit has been overcome to such an extent that it is the common practice among currant-growers to totally spur prune the vine. A large number of spurs are left in order to secure a heavy crop. The cost of pruning is thus reduced and the operation simplified. The fruit at the same time is more uniform in quality. In successful commercial practice there is no system of pruning in which rods alone are left. Certain devices have been tried with a view to abolishing the spur, but in practice they all fail, no matter what their theoretical claims may be. As the rod is established solely for fruit production, it follows that a definite number of spurs in proportion to the rods are needed for renewals

in the following year. To this end, the rule is to leave at least the same number of spurs as there are rods, but more generally the spurs exceed the rods in number.

The normal production of wood from a spur during the season will be two well developed canes; possibly, by reason of the base buds bursting, there may be more. In any case, having in view always the advisability of increasing or decreasing the number of secondary arms when seeking to renew the spur, one naturally selects the lowest suitable fruit-bearing cane, the rest being removed. When re-establishing a rod as well as the spur, it must be borne in mind that the rod must be fruit-bearing, and the new spur will be formed from the lower and the rod from the upper cane. As the spur need not in this case be fruit wood, it is preferable to use a well-placed water shoot rather than a badly-placed fruit shoot. In cases where only one fruit shoot is available, but where there are good water shoots in suitable positions, the rod is made from the fruiting cane and the spur from the water shoot.

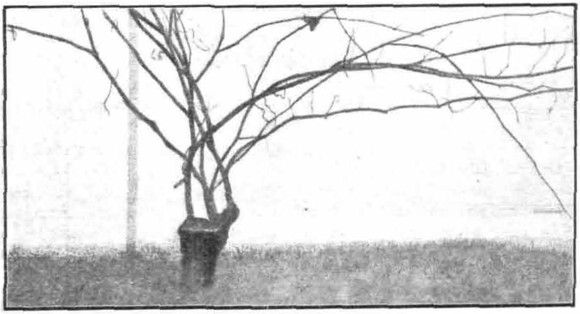

Fig. 9.—An old vine cut back through the stem showing several water shoots.

Should the choice be limited to one cane only, the rod must be temporarily abandoned in favour of the spur. Similarly, vines which are normally rod-pruned will be reduced to spurs only should they become unduly weak from any cause. The rods are again replaced if ordinary vigour is regained.

Much depends upon the judgment of the pruner in maintaining the balance of vigour. By overloading the vine with fruit-bearing wood, it is possible to so reduce the general vigour of the growth that in the following year there is little wood strong enough to renew the rods. Such an error of judgment may be due to climatic factors, but in any case the results are the same. Should the error be noted soon enough—such as, for instance, during a particularly dry summer—a good deal may be done if it is possible to remove a proportion of the rods by, say, the end of November. This has been done in times of drought with good results. The same may occur when for some

reason the setting of fruit has failed; then, having failed in their purpose, the rods may be removed if thought expedient. The only alternative upon a weakened vine is to temporarily suspend rod pruning until the normal vigour has been regained. This may be accomplished in one year, or it may take longer. It is impossible to lay down any rule as to the number of spurs and rods which vines generally may carry successfully, for the reason that so many outside factors are involved. The strength of the vine at time of pruning can only be gauged by the number and dimensions of the matured canes. Taking into consideration the amount of fruit-bearing wood carried in the previous year, the experienced pruner decides whether this should be increased or decreased. In all cases it is well to have a reserve on the side of the wood development, as it allows a margin for the possibility of a short rainfall. Apart from this, a vine which is working up to its maximum capacity of production every year will not last so long as one which makes more wood. The fruit from the more vigorous vine will surpass the weak one in quality, if not in quantity.

WATER SHOOTS.

The water shoot is not an unmitigated evil; in moderation it indicates a reserve of energy on the right side, and is useful in many ways. An excessive number of water shoots may be attributed to several causes. In the case of normally developed vines they may be induced by a period of conditions more than usually favourable to growth. The usual channels for outlet, represented by the number of buds left upon the pruned vine, are insufficient, and consequently water shoots break out from the latent buds. Such conditions must not be taken as indicating the need for more liberal pruning, and it would be unwise to make any material departure from the usual treatment of the vine.

When numbers of water shoots arise under ordinary conditions it is an indication of one of two things—either that the vine is being pruned too severely or that, the older and permanent wood being worn out, the sap flow breaks out through latent buds in the form of water shoots. In the first case, excessive vigour is first indicated by the bursting of base buds upon the spurs, and the remedy is found by increasing the number of spurs or rods which a vine may be carrying. In the second it becomes necessary to re-form the worn-out vines whose debilitated condition is indicated by very weak growth from spurs at the summit of the arms. Finally, we may find a number of water shoots forced out as the result of severe frost destroying the spring growth. This is an occurrence, fortunately rare, which implies a very short crop in the following year. There is no alternative but to use such fruit canes as may be available and re-form the vine from the water shoots. In all cases the surplus ones should be cut out as close as it is possible to get them. The remainder will be used as spurs in order to renew the portions killed by the frost.

A true water shoot—that is, one which arises from a latent bud upon old wood—is not fruit-bearing, but if cut back to a spur will produce canes which will develop fruit-bearing buds. In the succeeding pruning these canes may be used either as spurs or rods for fruit production. Their buds develop canes which will carry fruit, for the reason that they have behind them two consecutive seasons' growth. (See Fig. 7.)

In all cases, superfluous water shoots should be cut off below the base buds. If this is not done, they tend to grow again from year to year, robbing the fruit wood of much valuable energy, and proving a source of additional cost in pruning. The best way to deal with all unnecessary growths is to rub them off during the spring while in a soft condition and easily broken out. Skilfully carried out, this practice will go a long way to reducing the cost of winter pruning.

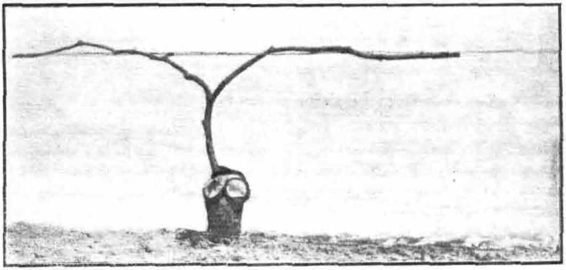

Fig. 10.—The same vine as in Fig. 9, pruned to form a new stem and main arms from one of the water shoots.

RENEWAL OF THE FRAMEWORK.

It has been previously pointed out that one of the aims of pruning is to prevent undue lengthening of the secondary arms of a vine. It becomes only a matter of time, however, when the annual accumulations from the base of the spur place the fruit-bearing wood at the summits of long, bare arms. No matter what care is put into the treatment of these arms, there comes a time when the general vigour of growth is reduced by the distance which the sap must travel and by the fact that its flow is more or less impeded by accumulations of scars created by pruning. It will always be found that the best results in quality of fruit will be secured when the wood producing it is vigorous and situated fairly close to the main branches. Apart from other objections, long secondary arms destroy the general symmetry of the vine and are more likely to be broken by teams during cultivation.

As a general rule, it will be found that the more fertile the soil, and given fair treatment, the longer will the secondary arms retain their vigour. It is not wise to unnecessarily interfere with the more permanent portions of the

vine, and, so long as they retain their vigour and do not hamper cultural operations, there is little occasion to shorten back. It should be remembered that large scars, such as those induced by removal of arms, are best avoided as they may lead to troubles, such as dry rot and its other attendant evils, white ants, borers, &c. Under ordinary vineyard conditions, however, there comes a time when the vigour of the fruiting wood diminishes, either by undue multiplication of the secondary arms or by the interruption of sap-flow, already referred to. Oftentimes, old vines which appear almost beyond recovery may be renewed by timely treatment. In the first place, if there is obvious overcrowding of arms, the removal of a proportion will result in renewed vigour for the remainder. Such a course of treatment has another advantage in the fact that removal of a number of worn-out secondary arms will most likely give rise to the development of numerous watershoots at or about the points of removal. These will supply the best possible means of renewal.

In all cases where old vines are carrying long secondary arms, it will be found that strong water shoots arise from time to time at some points on their length. Having in view the fact that water shoots are not fruit-bearing, the long arm is not suppressed right away unless the terminal growth is so weak as to be quite useless for fruit-bearing in the following season.

The plan adopted is to cut the water shoot back to one bud, with a view to securing one strong cane in the following year. At the next pruning thi cane will be carrying fruit-bearing buds, so that the old arm can safely be cut off, leaving a strong spur as the base of the new arm. In rod pruned varieties, where it is desired to replace a rod and spur, two buds will be left on the water shoot instead of one, in order to secure the two canes for re-forming. At the next pruning, the old arm can be cut away and a new spur and rod created from the two strong canes. (See Fig. 7.) One point which is too often neglected in renewal of arms is the smoothing over of the saw sections created by their removal. A rough section, as left by a saw, will not heal over, whereas if the surface is subsequently smoothed with a knife or secateurs, there is much more chance of its being absorbed by the developing tissue.

The vine responds to sympathetic treatment, and is not something which may be indiscriminately hacked about. In dealing with fully-formed and old vines, the experienced pruner, who should know the why and wherefore of his operations, looks two years ahead, assuring not only provision for the next crop, but renewal of worn-out wood in the seasons to come.

Although the necessity for renewing the main arms and stems of the vine is more remote than that of the secondary arms, the occasion does arise. Main arms can be replaced in the same manner as the secondary arms by establishing the base of a new arm from a suitably-placed water shoot. With trellised vines it may necessitate the use of a stout water shoot rod which will be trained along the wire to replace a worn-out or injured main arm. Upon this the secondary arms are afterwards built up. (See Fig. 8.)

Reconstruction of the whole vine by creating a new stem is the least likely, but, for various reasons, a possible necessity. Assuming that there is sufficient vigour in the root system to force out good water shoots low down upon the old stem, one of these can be utilised to re-create the framework of the vine. The growth from such a cane is very strong, as a rule, and until it becomes stout enough to support the weight of the young growth, should be securely staked or tied to a trellis wire. In either case the growth selected is cut back to such a height that its growth will serve to form the main arms of the new stem. From this point the whole structure of the vine has to be rebuilt step by step. (See Fig. 10.)

SYSTEMS OF TRAINING VINES.

The grape vine is, by natural inclination, a creeping or climbing plant adapted to trailing over some stouter plant or structure, in order to support its more or less slender stems. Under cultivation, by definite systems of pruning, the vine is established with a stout rigid framework, capable of supporting the weight of annual growth and fruit. The development of varieties has given rise to types of varying habit, some being more or less erect in their growth, while others retain the creeping characteristics of their wild progenitors. It is upon this habit of growth that the system of training is mainly dependent. Varieties inclining to the sturdy upright habit of growth are often trained upon the "bush" or "goblet" system, each vine standing individually with a stake to support its annual growth.

Those of trailing habit are generally trained upon a trellis, in which the permanent structure is built upon and supported by a tightly-strained wire. In most cases a second wire acts as a support to the annual growth, which clings to it by the aid of tendrils. For the greater part, the bush-trained type is spur pruned, while the varieties upon trellis are more adapted to rod pruning. In certain instances the rod and spur are applicable to both forms of training. Although no definite rule can be laid down for guidance, it will usually be found that the stout-caned varieties, with short internodes, adapt themselves to the spur pruned bush, while the trellised ones are longer in the internodes and more slender in their canes.

The Bush or Goblet System.

The perfect type in this system consists of a short, stout stem, of about 10 to 12 inches in height, supporting two or more main arms, according to the strength of the vine. These main arms may each be subdivided into two or more secondary arms, upon which the fruit-bearing wood is carried. The number of the secondary arms is limited only by the vigour of the vine, and may vary from four to twelve. Above this number it becomes difficult to allow space for them all, and when conditions of soil are such as to induce this excess of vigour, it will be found more satisfactory to adopt a system of trellising.

In the first place, it should be the aim of the grower to secure a strong, stout stem of a sufficient height to prevent the bunches of fruit from touching the ground when they are fully developed. For wine varieties it will generally be found that a stem with a clearance of 10 inches to the base of the main arms will be entirely satisfactory. Table varieties are sometimes trained rather higher, and may go up to 12 to 14 inches. In practice, some experienced growers train their vines even higher. This is more particularly so in the county of Cumberland, N.S.W., largely owing to the length of the bunches of the varieties grown. In South Australia and Victoria the tendency is to reduce the height of the stem as much as possible. The closer the fruit-bearing wood is to the soil the greater will be the proportion of sugar in the fruit, and therefore it is a disadvantage to increase the height of the stem unnecessarily. Provided that the young vine is supported by stakes during the years of formation, a 10-inch stem becomes stout enough to withstand the effects of wind pressure. The higher the stem the less resistance, and therefore the greater need of stakes.

The young vines at the end of the first year's growth will be carrying canes of varying strength. It is not wise to seek to establish the stem from weak growth, and therefore, unless a vigorous cane can be secured, it is wiser to remove all but the one cane and to shorten that back to a spur of two buds. Subdivision at this stage not only overtaxes the strength of the young vine, but it establishes the main arms too close to the ground. A strong cane is required which can next year be cut back to the required height. This stage in formation is figured in the illustration, Fig. 11A, with the resulting growth in the following summer. In some cases it is the practice to allow but one cane to develop, all the others being disbudded. Such a practice requires very careful treatment of the selected cane, for, in case of accident, there is no other as an alternative. Apart from this, the unnecessary interference with the foliage of young vines is not to be recommended. Most young vines will carry two good canes quite satisfactorily.

The next step in the training is shown in Fig. 11B, the best available cane being cut back to rather more than the height of the proposed stem. The second bud from the top should be about the height, as the main arms will be developed from these two or three buds. It is well to leave a long internode above the topmost bud in order to tie to the stake. The growth from this stem will vary, but there should be no difficulty in securing, at any rate, two main branches at the next pruning. The pruner must exercise his judgment and establish the arms according to the strength of the vine. Each vine must be treated individually, pruning it in accordance with its growth, for the reason that it is rare to find absolute uniformity in any number of young vines.

Fig. 11C shows the stem with two main arms established, each consisting of a strong two-bud spur. In addition, one spur shows a well-developed base bud. The summer growth is illustrated as five good canes from which the secondary arms will be chosen. These canes will in all probability have carried fruit during the summer.

In Fig. 11D the vine is shown pruned with two spurs upon each main arm. The choice of these spurs should be from the canes best designed to give a symmetrical formation to the crown of the vine.

Although four spurs are figured it may be advisable in some cases to create only three, or it may even be necessary to reduce to two again if the growth is weak. The illustrations only follow out the general idea of development, and must not be taken as a definite rule. Naturally, in figuring a subject diagrammatically the more or less ideal condition is accepted, though in practice all manner of variations and difficulties arise. It is here that judgment and skill on the part of the pruner are required to make the best of unsatisfactory conditions. The resulting growth from Fig. 11D is figured as eight good canes which will have fruited during the summer.

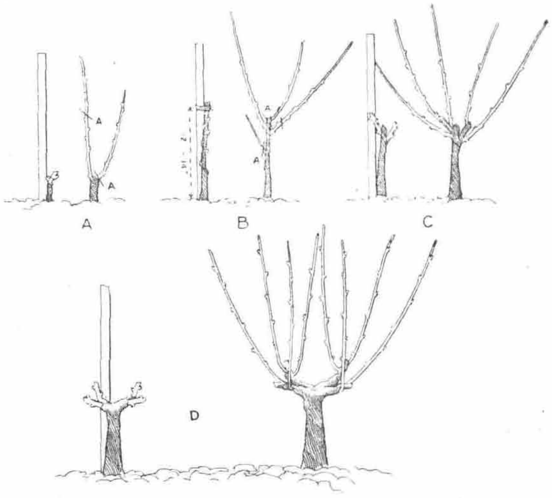

Fig. 11.—Diagrammatic representation showing the formation of the bush vine.

From this stage the formation may rest with the annual renewal of one spur upon each arm, but more generally the number of secondary arms will be increased to five, six, seven, or eight at intervals of one or more years. This may be taken as a good average; but instances arise when a further increase is warranted as the vines become older and stronger.

The vine may now be considered as definitely formed according to plan, and its future treatment consists in annual renewal of fruiting wood with due regard to vigour and shape of the vine. In the case of vines that

continue to show more than ordinary vigour, additional spurs may be created with a view to securing heavier crops. On the other hand, when there is evidence that the vines are being overloaded to such an extent that the growth is becoming weak, the spurs will need to be reduced in number. The same result will possibly be achieved by reducing the spurs to one bud instead of two, as a temporary expedient.

In the course of years secondary arms tend to become overlong, and methods already described should be resorted to in order to reduce them to normal length. Under this system of training there is no cost of trellising, although there is, of course, the cost of stakes to be taken into account for the early years of the vine at any rate. Cultivation is more economical, for the reason that it is quite possible to cultivate in several directions when the vines are planted at suitable distances. Hand labour is thus reduced to a minimum.

The varieties which may be trained upon the spur pruned bush comprise the following:—Mataro, Grenache, Carignane, Frontignac, Pedro Ximenes, Black Hamburgh, Muscat Hamburgh, Doradillo, Muscat Gordo Blanco, and most of the table grapes.

The Rod Pruned Bush Vine.

On grounds of economy in the cost of establishing a vineyard, the rod system is sometimes applied to the bush-trained vines, instead of erecting a trellis. Although this may be considered false economy in many ways, the fact remains that a fair measure of success is obtained from the practice. It may be applied equally well to vigorous specimens of the varieties mentioned, when grown upon soils of more than average fertility. As a means of checking rampant vigour, the use of one or more rods for fruit-bearing secures to the grower a much heavier yield from these soils.

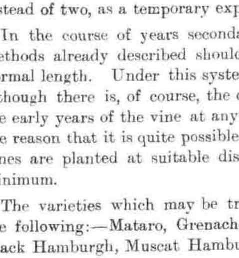

Fig. 12.—Spur pruned bush vine.

Any of the spur pruned varieties mentioned in the preceding paragraph will respond to this treatment. In addition to its application to this particular class of vine, others which are usually trellised, such as Shiraz, Carbenet, Riesling, Malbeck, &c., may be trained on similar lines. At the same time it must be borne in mind that these latter varieties yield the best returns when systematically trained upon a trellis. The rod pruned bush can only be looked upon as a possible substitute.

In all respects the vine is developed from year to year in exactly the same manner as described for the spur pruned type, and until the formation is completed it would be unwise to adopt any regular system of rods. The

number of spurs will equal, and in most cases exceed, that of the rods, and, generally speaking, it will be found that from three to four rods to six spurs will be sufficient. The rod must be looked upon as temporary, to be removed at the pruning subsequent to its having fruited. The spur will be given choice of position in so far as it will maintain the shape of the vine, and provide strong canes for the next season. For this reason it is not absolutely essential that the spur shall be fruit-bearing, although, for the sake of the grape crop, it is preferable that it should be so. It frequently happens that a good water shoot occupies a position superior to that of a fruit shoot. This is more frequent in the case of old vines than young ones, and wherever the opportunity arises, it is well to make use of these canes to improve the shape or renew the arms. Should the pruner think it preferable, a fruiting spur, even though it be in a bad position, may be left for the time being, but provision should be made for the next year by leaving one bud upon the water shoot, from which a cane can be secured later on.

Having selected the spurs, the requisite number of rods will be reserved from good fruit-bearing canes, while the remainder will be cut away. The general plan adopted to secure the rods in this system of pruning is to bend them over the top of the vine, intertwining them in the form of a dome. If preferred, the ends of the rods may be tied down to the extremities of the spurs, in which case a long internode should be left upon both spurs and rods, with the enlarged portion of the rods to prevent the tie from slipping. The plan of twisting the rods is the one more generally adopted, as it is quicker and just as effective. The objection may be raised that this system leads to overcrowding of the foliage; but so long as the strength of the vine is not overtaxed and the spurs are given good positions it does not matter. The system is in no way claimed to be as good as the trellis, but is merely an economical substitute. So long as the vines retain their vigour the system may be practised, but so soon as they show evidence of weakness the rods should be reduced in number or done away with altogether. (See Fig. 13.)

Fig. 13.—Rod pruned bush vine.

A variation of the foregoing plan is sometimes adopted when the rods are twined around a strong central stake more or less spirally. A stake is in all cases an advantage, supporting the growth and creating greater stability against violent winds.

TRELLISED SYSTEMS.

Grape vines are trained upon trellises for several reasons, the chief of which, under commercial practice, is the utilisation of the vine's vigour to its fullest extent. This is to say, that no matter what claims the respective modifications of the bush system may possess, in many cases, satisfactory

results can only be assured by systematically training the vines upon a supporting trellis work. This is so, because there are some vines whose strength and habit of growth render any other method ineffective. Others which may adapt themselves to the bush under conditions of moderate vigour, demand greater scope for growth when placed upon very fertile soils or under irrigation. Take, for example, the Zante Currant, Sultana, Shiraz, Malbeck and Crystal, all of which are most unsatisfactory when trained as a bush vine, no matter whether they be in poor or in fertile soils.

These systems of trellis training are adapted to both the spur and rod-pruned varieties, the scope of development being only limited by the vigour of vines under given conditions, and the distance at which they are planted apart. Thus we find in practice that certain of the weaker-growing varieties are trained generally in a manner adapted to close planting. The same vines will need greater scope for development as the fertility of the soil produces greater amounts of wood. It may therefore be necessary to adopt some different or modified system of training to suit varying conditions. A uniform system of training upon a trellis would be as ineffective as the universal adoption of the bush to all varieties. As the outcome of experience we find that a number of different forms of trellis-training have been evolved, and these are adapted to all class of vines, under a multiplicity of conditions. Instances may be cited of vines such as the Zante Currant, Sweet Water and Crystal being trained in such a manner as to give 30 to 40 feet of main arm. In individual cases they run to much more than this length.

The aim should be in every system to utilise the full length of the trellis as a support to fruit-bearing wood, by building upon it the permanent arms reaching from vine to vine, or by extending annual rods from shorter arms.

It is a more or less popular conception that trellising a vine is simply a matter of allowing the canes to ramble as nature dictates over a supporting framework.

Such is not the case, however, as in the best forms of training the vine is built up step by step upon a definitely conceived plan of construction Such plans have always in view the utilisation of all space for fruit production, and the maintainance of vigorous fruit-bearing wood from year to year. Further, all the systems of trellising take into account the laws of nature with reference to the growth and fruit-bearing of the vine. In this respect it will be found that the greatest measure of success is attained by training the vine in such a manner that the main arms, springing from a vertical stem of varying height, are maintained in a position as near to the horizontal as it is possible to get them. Subsequently the secondary arms, carrying the fruit-bearing wood, are built upon the main arms at regularly spaced intervals Modifications must, of course, arise to suit special cases, such as, for instance, the creation of two or more sets of main arms at different levels upon strong-growing varieties like the Zante Currant. Wine varieties more generally respond to the simpler forms of training, for the reason that they are mainly grown upon soil of only average fertility.

For simplicity of description, the systems of training may be divided into two: those in which the main arms (two or more in number) are placed on either side of the stem—usually termed espaliers or spaliers—and those in which the main arm is placed on one side of the stem only, known as cordons.

In the first instance the arms are trained horizontally upon the wires, right and left of the stem, and in the simplest form there are two arms. In certain cases modifications are adopted, two or more pairs of arms being obtained at different levels. Although such modifications may not, from the theoretical point of view, be the best treatment, in practice they afford a means of overcoming difficulties in handling the accumulations of growth from a strong vine.

The objection raised against the two-armed, or spalier, vine is the possibility of uneven sap distribution, to the ultimate upsetting of the balance between the arms. This applies more to those vines which are trained with long permanent arms than in the simple forms of spaliers, with short and easily renewed main arms. It follows that when one arm, for some reason or other, secures a margin in the vitality of the vine it will naturally use this preponderance of vigour to the detriment of the weaker member. In this way the difference in the vigour of two arms may become more marked, to the ultimate failing of one half of the vine.

When there is but one arm, as with the cordon, it represents but the one main channel for supply of the sap, and therefore any fault in distribution can only affect the secondary arms. It would appear to be more natural to divide the crown of the vine when training and to develop the two-armed type. In addition, this system is more generally known in Australia than the cordon, and it is therefore more generally adopted. Nevertheless, the cordon has many advantages, and where adopted has given excellent results. It applies to best advantage in the case of vines growing upon rich soils, where the nature of the growth enables the main arms of individual vines to meet.

Where trained as a spalier the arms of the vines meet mid-way, while in the cordon the one arm is carried on until it meets the stem of the next vine, or until limited by the strength of the vine.

The same systems of training, both spalier and cordon, are adopted very largely in currant growing. The vigour of the Zante currant under normal conditions of culture, or under irrigation, makes it imperative that a system allowing of full development of the vine shall be adopted. Thus we find that there is a tendency to resort to double- and treble-decked modifications in order to curb the vigour of this particular vine.

Whether such a practice is the best in the long run is questionable. The simpler the construction of the vine the better the ultimate results, and if this strength of the vine will warrant say 12 feet of main arm well furnished with secondary arms, it is better to have this built up all on the

same level than to have the vines half the distance apart with double-decked arms. The only point to be considered is that the one arm may take longer to build up.

The same systems may be applied to strong-growing table grapes in rich soil. It is at times asserted that the long arms have been a failure, but when this has been so it will usually be found that the failure is the result of one of two faults in construction.

Firstly, there is a great tendency to extend the arms too quickly from year to year, resulting in an excessive number of buds to be nourished. It then happens that the individual growths from these buds are very weak, or else that a portion of them fail to burst, leaving a poorly-furnished arm. *The secret of successful formation lies in the establishment of a stout arm,* liberally furnished with strong, vigorous canes to start the secondary arms. None but a strong cane should be used to start a main arm, and it should be so extended that all the buds will give rise to good-sized canes.

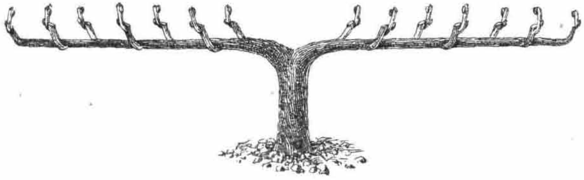

Fig. 14.—The Thomery Spalier, spur-pruned.

The second mistake lies in extending the length of the arm to such a limit that it overtaxes the ability of the root system to nourish the amount of wood and fruit which it is capable of carrying. This is a common trouble in vines of only ordinary vigour. The trouble becomes accentuated when *the sun, through lack of foliage, dries up the main arm, interrupting the free flow of the sap.* Weak or dead secondary arms ultimately arise, and frequently nature asserts itself in forcing numerous water shoots from the stem or other healthy portions of the vine.

For these conditions modified forms of the systems are used, having, as a rule, short main arms, upon which the fruiting wood is renewed from year to year in the form of spurs and rods.

For general wine-growing conditions, the short-armed types of training are very satisfactory, and they adapt themselves to the majority of the wine varieties of grape. Table grapes, which are generally grown under more favourable conditions of soil and climate, may, by reason of the greater vigour induced, be trained on the more extended forms of spaliers and cordons. The Zante currant is extended similarly, even to the extent of creating more than one set of main arms.

The Sultana vine, on the other hand, in spite of its great vigour, does not respond if the main arms are over-long. The system most usually adopted for this vine is to establish a stout stem, with two short arms of about 15 inches in length, upon which a number of strong fruiting rods are established from year to year, in conjunction with a number of spurs for renewal of wood. Some growers entirely eliminate the arms with the Sultana, and have simply a straight stem, at the summit of which the fruiting rods and spurs are placed. This arrangement would appear to be going to the extreme, but nevertheless, satisfactory results are secured under certain conditions.

Fig. 15.—Note loss of space owing to faulty formation at the crown in A.

The Thomery Spalier System.

This system of training is one well adapted to strong-growing table varieties, or vines growing under irrigation. The typical vine consists of a straight stem which may be of variable height, and which has at the summit of this stem two strong arms extending one on either side of the vine to form as near as possible a perfect T. The length of the arms is adapted to the vigour of the vine and the conditions under which it may be growing. Upon the main arms the secondary arms will be distributed at even distances, and upon these will be placed the fruiting wood. This latter may be in the form of spurs only, or else a combination of spurs and rods.

The use of spurs only will be adapted to table and other varieties which bear satisfactorily from the spur. The present day practice in growing Zante currants is to use the spur rather than the rod, the number of spurs being increased to balance the vigour. When this method is used the spacing of the secondary arms will be much closer than for the spur and rod; roughly speaking, 6 inches apart will suffice, but the actual arrangement rests largely with the man who is pruning the vines.

When the combination of spur and rod becomes necessary by reason of the character of the variety the spacing of the secondary arms will be wider, and here again the ultimate arrangement depends a good deal upon the skill of the pruner. Fig. 14 illustrates this system of training.

Formation.—As in other systems, the foundation of the stem and main arms should not be established from weak, spindly canes. Assuming that the young vine as planted into the vineyard is a good, one-year-old rootling, it will be cut hard back to a short spur at time of planting, in order to secure one or more strong canes, and to allow the root system to develop.

At the end of the first year the young vines will, in most cases, be again cut back to a two-bud spur. One of the desirable objects of this system is to ensure that the main arms come from as near the same level as possible, and in order to secure this a certain amount of manipulation of young growth becomes necessary, by which several buds are secured at the same level. From the growth of these buds the arms are established.

An imperfect form of the system is frequently seen when the arms are started from canes with an internode between them. The outcome of this is a more or less pronounced Y below the level of the wire instead of a T, which may ultimately act to the detriment of one or other of the arms. (See Fig. 15.)

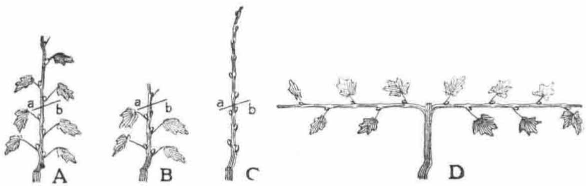

Fig. 16.—Showing manipulation of young growth to secure buds close together as in C, and the two canes being trained in D to form the main arms.

The mode of procedure is as follows :—A good strong young cane is trained vertically in the spring, and when it is about three or four internodes above the wire which indicates the height of the stem the tip is broken off above a bud which is just below the wire. In the course of a week or so the terminal bud remaining begins to grow another shoot, and when this is an inch or so in length it is again pinched back. This treatment results in a number of buds being established very much on the same level. The normal growth is now allowed to proceed throughout the growing period.

At the next pruning the stem is tied vertically and firmly to the wire. In the spring two or more canes will start from about the same level, and may be trained on either side along the wire. (See Fig. 16.) These canes should be carefully trained along the wire throughout the season, keeping useless growth thinned out in order to foster the strength of the main canes.

At pruning, in the following winter, the two main canes should be shortened back according to the vigour of the vine. A common mistake of pruners is to make these arms too long in the first year, the effect being to cause a weakening of the individual canes in the next season, for the reason that there are too many buds to nourish. A further defect frequently results, in that the buds near the base of the arms may fail to burst and those at the extremities become over-strong.

The result to be desired is a strong cane from every bud left upon the arms. In all cases the terminal bud should be left underneath and a full internode should be left for tying to the wire. In general 2 feet to 2 feet 6 inches should be long enough. (See Fig. 17.)

The vine now consists of a T-head forming two arms, and upon each arm several strong canes, with a vigorous one from the terminal bud which is to be used in the extension of the main arm. The vine will now be producing fruit, though it is not wise to allow over-production at this stage with consequent weakening of growth.

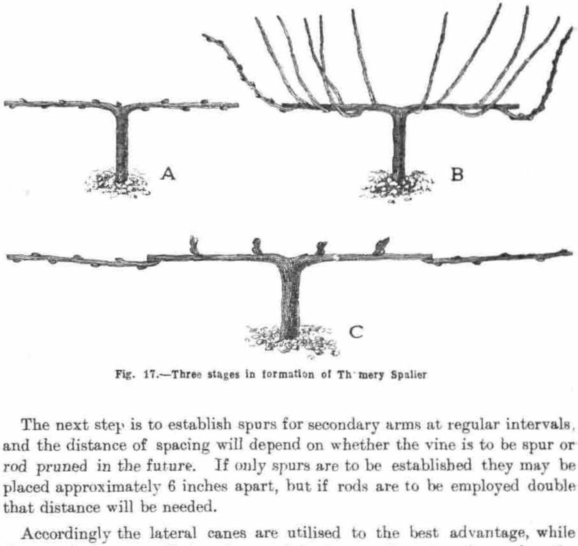

Fig. 17.—Three stages in formation of Th mery Spalier

The next step is to establish spurs for secondary arms at regular intervals, and the distance of spacing will depend on whether the vine is to be spur or rod pruned in the future. If only spurs are to be established they may be placed approximately 6 inches apart, but if rods are to be employed double that distance will be needed.

Accordingly the lateral canes are utilised to the best advantage, while the terminal ones will be shortened back according to vigour for the extension of the arms, say, to a further 2 feet in strong vines, again leaving the terminal bud underneath.

When establishing the spurs which are to form the secondary arms, it is not advisable to place them too close to the base of the main arm. The general rule is to have the first ones about 9 to 12 inches from the centre of the vine, thereby insuring a more even distribution of the growth. The tendency is for spurs which are placed closer than this to absorb too much sap and to become over-strong in relation to the growth further along the arm.

The foundation of the vine is now well established, and it is simply a matter of extending the arms from year to year so far as the vigour of the vine will permit. At the next season's pruning the first thing to be done is the renewal of the fruiting wood on the base portion of the arm. If the vine is spur-pruned it is merely a matter of renewing the spurs by reducing the most suitable canes to two-bud spurs. Should the variety be a rod-pruned one the two growths developing from the old spurs will be converted—the lower one into a new spur and the upper into a rod. The latter will, in general, be tied down to the wire by the terminal internode which has been cut through the base of the bud.

The canes on the previous year's extension will be spurred similarly to the preceding portion, thereby establishing a further number of secondary arms. The terminal canes will be used to extend the arms to a greater length.

This process continues until the full extent of the arms has been reached, and finally each arm is terminated by a spur.

Annual Pruning.—According as the vine is spur or rod pruned, the annual treatment is on recognised lines. Provided the vigour of the vine is normal there should be no difficulty. The spurs in either case will be selected from such canes as will contribute to the shape of the vine, and at the same time keep the secondary arms as short as possible. The rods, being for purpose of fruiting only, may be placed anywhere, provided that they are fruit-bearing wood.

The ideal arrangement is to form the new spur from the lowest suitable cane, and the rod from the upper, but this cannot always be attained. The spur must have preference over the rod if it is impossible to secure both, and for the time being a rod may be secured, if need be, from a cane on the old rod. All water shoots growing upon the stem or arms should, if possible, be disbudded in the spring, and failing this they must be cleanly cut out at the winter pruning.

As the vine becomes old the secondary arms will probably need renewal by the use of suitable water shoots which may arise from time to time. The vigour of the vine should be maintained, and weakening from over-production should be specially avoided. In the case of rod-pruned vines, where excessive weakness is evident the rods should be dispensed with for one or more seasons, enabling the normal development of wood to be renewed.

Multiple-armed Spaliers.

The necessity for more than one pair of arms may arise in certain circumstances, and necessarily implies great vigour of growth in the vines. It is confined, for the greater part, to strong vines grown under irrigation, such as the Zante currant, or other strong vines growing under natural rainfall on rich soils.

In the first place a high trellis-work is needed, with wires at heights suited to the scheme to be adopted. The young vine must have a strong start, and a stout cane will be tied vertically to the trellis wires. The principal point

to achieve at the outset is the production of a number of strong canes at levels which will coincide with the levels of the wires. It becomes impossible to insure that each pair arises at the same level, and therefore the best possible arrangement must be made.

From the vertical stem the most suitable canes are trained on the various wires, shortening them according to the strength of the vine. In other respects, once the first section is established, extension of the several arms is on lines similar to the Thomery spalier. Greater precautions may have to be observed owing to the multiplicity of arms, and every care must be taken to see that the strength of the vine is not overtaxed.

With regard to the annual pruning, practically the same remarks apply as in the simple spalier type. Indications of permanent weakness in the old vine are remedied by the removal of one or more pairs of the arms.

The main objection to the multiple-arms types of training is that the top arms overshadow the lower ones with possibly some disadvantage to the fruit on the latter. Some of the best currant vineyards on the Murray are single-armed types (spaliers and cordons) and, as mature vines, they are very productive.

The Bordelais Spalier System.

A system more applicable to vines of average strength than those already described is furnished by the Bordelais spalier. It is adapted to all the rod-pruned varieties, and may be utilised for vines of varying degrees of vigour by increasing or decreasing the number of rods which may be left from year to year.

The type consists of a short stem about 12 inches to 15 inches in height, carrying two short arms, which form a more or less pronounced V and has a trellis wire placed 18 inches from the ground. Upon these arms the spurs and rods are situated; the latter, varying in number from two to six, are tied down to the wire on either side of the stem. (See Fig. 18.) The spurs are intended for renewal of fruiting wood from year to year, and therefore need not necessarily be fruit shoots. Strong, well-placed water shoots are preferable to weak or indifferent fruit shoots. The rods are purely fruit bearing, and are renewed annually from the most suitable fruit-bearing canes. To this end it sometimes becomes necessary to make use of a good cane growing from the previous year's rod, when from some cause or other there is a shortage of suitable wood upon the spurs.

Although the height of the stem is set down as from 12 to 15 inches, and that of the wire at 18 inches, these may be varied to suit special circumstances. Generally speaking, however, the height to the first wire need not exceed 2 feet 6 inches. The number of wires is also variable from one to two, and if the second one is adopted it will generally be about 18 inches above the first. In some cases the one wire is considered sufficient, but in others the second is an advantage, in that it serves to support the annual growth in the trailing varieties.

Formation.—Shorten the best cane back to a single spur of two buds the first year. In a large measure the success of the training depends upon making the stem from a good strong cane. Too often one sees the result of bringing a very weak cane up to the wire in order to form the stem, more particularly if the vine is trained at a greater height than that set down in the type. A weak and spindly stem created before the vine has sufficient strength to support it will rarely make up into a strong vine, and in time the whole plant suffers, and it may die, where a stouter vine will pull through.

Second Year.—Assuming that one or more strong canes are available, the stem can be formed, but failing this the vine should again be cut back

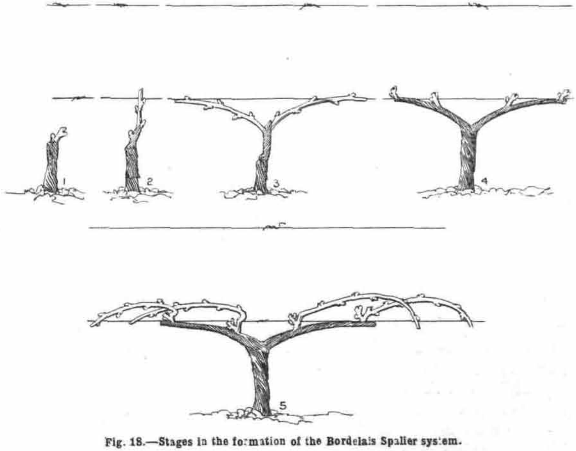

Fig. 18.—Stages in the formation of the Bordelais Spalier system.

to a spur. It is a mistake to use a cane which is too weak and short to reach the wire, and to attach it by a piece of twine. The best plan in such circumstances is to cut right back for this year. When the growth is of good strength, take the best cane, shorten back to the height of the wire, tying vertically and securely in that position. It is a good plan to cut a little on the short side so that the wire has to be depressed a little. The slight strain thus imposed serves to keep the cane rigid and vertical. The topmost internode should be cut right through the node, leaving the enlarged end to prevent the tie from slipping. (See Fig. 19A.) In no case should a live bud be left above the tie, as this would create a strong cane in a useless position.

Third Year.—The vertical stem now carries several canes at varying heights, and from these the two main arms will be formed. The usual plan is to select the two uppermost canes, provided that they suit the purpose, reduce them to a length of 12 to 15 inches, and tie each down to the wire on either side of the stem. The remaining canes are completely removed. This then creates the stem with two main arms, established somewhat in this form: (See also Fig. 19B.)

It must be remembered that the vine will most likely have carried fruit during the past year, but the tendency to produce fruit to the detriment of wood should be discouraged in the early stages of formation. It may be advisable to reduce the number of canes produced upon the second year's formation to the two which will ultimately be used to create the arms.

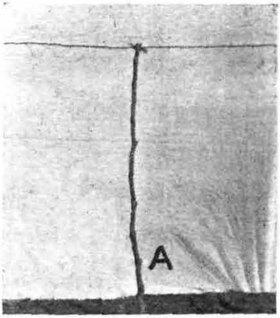

Fig. 19A.—A two-year-old vine cut back and tied to the wire.

Fourth Year.—The two main arms will each be carrying several good canes, and it is from these that the secondary arms will be established. The number will vary with the strength of the vine, and in some cases an addition of one rod upon each arm can be made. Generally speaking, the spurs will be from two to three in number on either arm, but in most cases two will suffice. Should a rod be warranted by reason of great vigour in the vine it will be left at the extremities of the arms and tied down to the wire. It is very unwise to sacrifice the strength of young vines for too much fruit, as the weakening at this stage is rarely recovered. The strongly built young vine is the one which will yield heavy crops over the greatest number of years.

Fifth Year.—The framework of the vine may now be said to be established, and each of the spurs left in the fourth year should be carrying two good strong canes. If a rod has been used as well, its purpose will have been fulfilled, and in the ordinary course of pruning it will be removed. The lower cane on each of the old spurs is shortened back to form a new spur

of two buds, and the upper one becomes a new rod. The length of these rods will be adapted to the vigour of the vine, and should not, as a rule, exceed about 18 inches. It may be advisable under certain circumstances to omit the formation of one or more rods. The general rule is that the number of spurs should equal or exceed that of the rods, and their ultimate disposal rests with the judgment of the pruner.

Although the foregoing practically concludes the development of the vine's structure, the system can be extended to meet special conditions. By the extension of the arms in strong vines, the number of spurs and rods can be increased as the occasion may arise.

Annual Pruning.—The annual pruning of the Bordelais spalier consists of the renewal of spurs and rods. The spurs are given preference of position in so far as they may affect the shape of the vine. In this respect, well placed and vigorous water shoots might be given preference over badly-

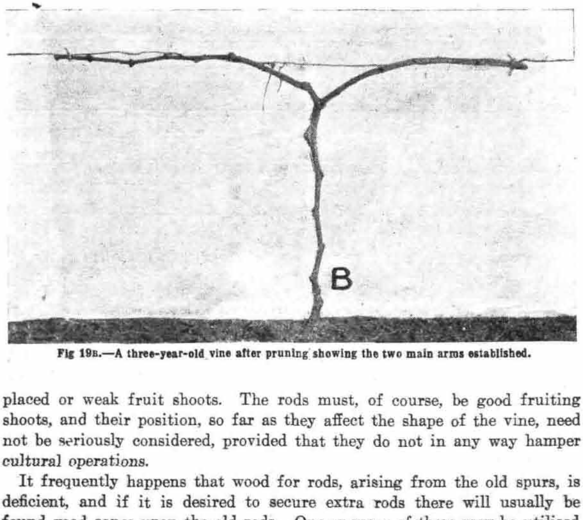

Fig 19B.—A three-year-old vine after pruning showing the two main arms established.

placed or weak fruit shoots. The rods must, of course, be good fruiting shoots, and their position, so far as they affect the shape of the vine, need not be seriously considered, provided that they do not in any way hamper cultural operations.

It frequently happens that wood for rods, arising from the old spurs, is deficient, and if it is desired to secure extra rods there will usually be found good canes upon the old rods. One or more of these may be utilised as fruiting rods for the time being, and they will be removed in the following season.

As the old secondary arms become worn out, they may be renewed from water shoots suitably placed for the purpose. In time it may be necessary to renew the main arms, and even the stem may, under certain conditions, require renewing. The procedure to be adopted in these cases has been dealt with in a previous article.

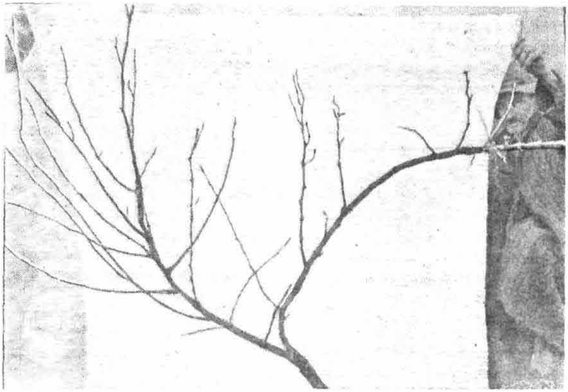

Fig. 20.—A vine in which the main arms have been started too close to the ground, and which illustrates the results of faulty tying.

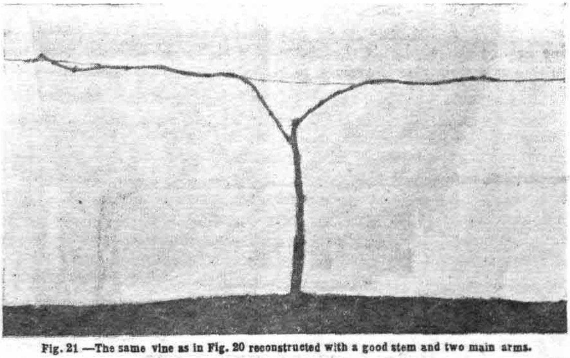

Fig. 21 —The same vine as in Fig. 20 reconstructed with a good stem and two main arms.

In dealing with the rods the end section should be made through the node, leaving a dead internode for tying to the wire. The practice of leaving a live bud at the end of the rod and tying below it is a mistake, for the reason that this bud, in spite of the ligature below it, usually makes abnormally strong growth at the expense of the intermediate buds.

Twisting and bending the rods when tying them down has a very beneficial influence upon the bursting of the buds. The nearer they approach the horizontal the better do the buds burst as a rule. Secure tying to the wires is important. Twine is most generally used for this purpose, but probably the most useful tie is 26-gauge black wire. The rolls can be cut into lengths suitable for the purpose, and owing to its great pliability it can very easily be twisted around the wire and rod. If one turn is first taken around the trellis wire, and the rod then tied to it with about two turns, it will neither slip nor give way during the season. Being black wire, the pieces rust away in the course of two or three years, whereas galvanised wire does not rust, but hangs indefinitely. The evils of bad tying are illustrated in Fig. 20.

The Bordelais spalier system is sometimes adapted to a higher stem, but the formation is practically the same in each stage. A common error is found when the main arms are started too close to the ground, resulting in a very long armed V, as illustrated in Fig. 20. This will ultimately result in a badly furnished vine with all the wood at the summit of bare arms. Fig 21 shows the same vine reconstructed with a good stem and two main arms. When the vines are comparatively young the reconstruction can be effected fairly easily, but where the arms have become too stout, the only hope of remedying the evil is to train a good water shoot into a new stem. By following the steps in formation methodically and tying securely to the trellis wires, the bad results illustrated in Fig. 20 are avoided, and once the stem becomes rigid it supports the weight of the vine against the wind. It then becomes a matter of securely tying the fruiting rods from year to year.

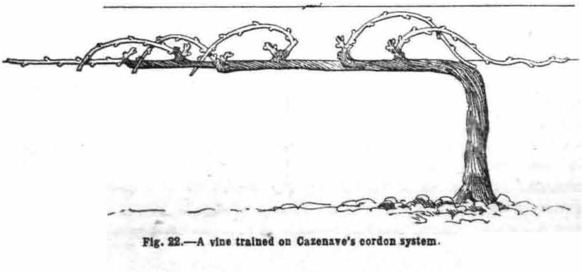

Fig. 22.—A vine trained on Cazenave's cordon system.

Cazenave's Cordon System.

The fully developed type consists of a stem varying in height, with one main arm carried horizontally along the trellis wire until it meets the stem of the next vine (see Fig. 22). Circumstances may limit the length of this arm, but in any case the process of formation is the same. The system may be adapted to either spur or rod pruned varieties, differing only in the distance apart at which the secondary arms are situated. As already stated, it is a system best suited to strong growing varieties of wine grapes, table grapes, and currants.

Formation.—The young vine will be shortened back to a single spur. It is essential that a strong cane shall be secured, sufficiently long to reach the trellis wire, and to admit of a portion of it being laid along the wire. This can only be accomplished by encouraging strong growth in the early stages.

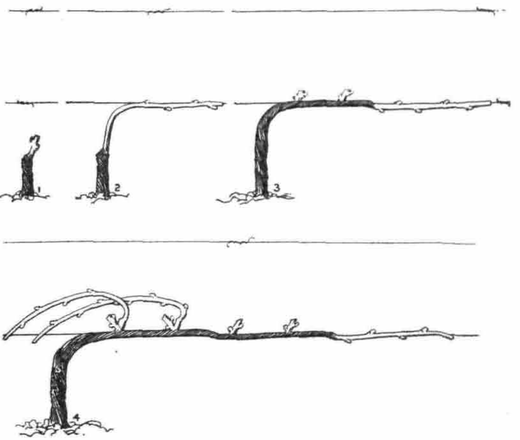

Fig. 23.—Stages in the formation of Cazenave's cordon system.

Second Year.—The height at which the stem is to be established very largely determines the treatment in the second year. Where the stem is established at about 20 inches there is no difficulty in securing a cane long enough to reach the first stage of formation. Assuming that such is the case, this cane is drawn up vertically to the wire, and then bent into a horizontal position along the wire. The extent of this horizontal arm depends on the vigour of the vine, but in any case it should not exceed about 2 feet 6 inches. Should the cane be weak it is better to shorten back again for another year.

The end section will be made through a node to facilitate tying, and the terminal bud will be underneath. Permanent twisting of an arm around the wire is not to be recommended, but in order to hold the young arm firmly in position until it has set, a slight twist is a good thing. By the end of a year the twist can easily be taken out, and the arm will retain its position.

One important point to be observed in formation is that no shoots are allowed to grow from the stem when once it is established. Further, it is not advisable to allow any canes to develop upon the arm within 12 inches of the bend with the stem. The tendency is for canes in this position to become over strong in relation to those further along. Two courses are open, the better of which is to remove the buds not required at time of pruning, and the other is to disbud the young shoots as they break out in the following spring. The important canes should be tied and protected from injury.

When the vines are being trained at a height of several feet, it becomes necessary to train a cane vertically on a stake, by stages if necessary, and when long enough, to start the main arms as described.

Third Year.—The canes which have grown upon the first section of the main arm will be used to form the secondary arms. The spacing will vary, as in the case of spaliers, being much closer when the vine is to be permanently spur pruned. In this case the spurs may be placed about 6 inches apart, whereas the spacing will be from 12 to 14 inches where the rod and spur are to be employed. The terminal cane will be used to extend the main arm another section, leaving the last bud on the lower side and tying firmly to the wire (see Fig. 23).

Fourth Year.—The development of the secondary arms will be continued. From the canes produced upon the previous year's spurs, renewals will be made, either as spurs only or as combinations of spurs and rods. In the former case the lowest suitable cane will be reduced to a two-bud spur. In the latter the upper cane becomes the rod, while the lower one forms the new spur. The spurs upon the extension are spaced for the continuation of the secondary arms, and at the same time a further extension of the main arm is effected by means of the terminal cane.

Fifth Year and After.—The formation is carried on upon similar lines until the limit of construction has been reached, that is, when the main arm meets the stem of the next vine, or when the vigour of the growth indicates that the limit has been reached. In strong-growing vines there should be no difficulty in carrying the main arm to the stem of the next vine, and it is only in the training of strong-growing vines that this system should be used. Weak-growing varieties, or vines under conditions unlikely to create vigour, should be trained upon some other system such as the bush type or the Bordelais spalier.

Finally, the complete vine has a horizontal main arm furnished with secondary arms, which support the fruit-bearing wood.

Annual Pruning.—The first care is to maintain the vigour of growth by so adjusting the fruiting wood that the strength of the vine is not overtaxed. That is to say, the wood should be of good vigour after the production of a normal crop. Weakness should be met by a reduction in the number of spurs and rods for the time being. As already pointed out, this system is one which necessitates vigour in order to secure best results, and to this end the vines should not be overburdened with spurs and rods. Under conditions of normal vigour the fruiting wood is renewed by the selection of the most suitably-placed canes. When the system is a combined rod and spur the former will be temporarily dispensed with when the growth is abnormally weak. The rods must in all cases be fruit-bearing wood, but the spurs may be established from strong and well-placed water shoots rather than from weak fruit shoots. As the vines become old, renewal of secondary arms will become necessary, and this renovation can be effected by using suitably-placed water shoots.

TRAINING THE VINE IN THE HOME GARDEN.

In the average suburban garden of the cities and towns of Australia the grape vine is popular, but only in a few instances do we find the most made of the plant, by reason of the lack of system in training. In the majority of cases the vines are allowed to ramble at their own sweet will over some supporting structure which is dignified by the name of "trellis."

As a shade plant, the grape vine has few equals, providing cool arbours in the summer when protection from the sun is most desirable. At the same time it has the advantage of being deciduous, losing its leaves in the winter, when air and light are appreciated. The return in fruit from a few well chosen and well cared-for grape vines is remarkable, and should prove sufficient for any average household. The common mistake made is in planting a large number of vines which are often more or less neglected, or are trained in such a manner that the fruit is inferior. Moreover, a few good vines are more easily cared for and protected from disease.

The varieties should be adapted to the conditions of climate under which they are to grow. For instance, varieties adapted to this State's coastal conditions are few in number compared with those suited to the less humid climates of the south and west. The grape which stands easily first in favour in and around Sydney is the Black Muscatel (Muscat Hamburg). In quality and fruit-bearing it has no peer. As the next choice, Black Hamburg may be taken, but beyond these two there is no great choice. The White Muscatel is erratic in its fruiting, in addition to being more subject to disease. Doradillo, commonly called Late Sherry, is a useful late variety, but it needs considerable spraying to protect it from black spot. This latter is, however, not such a serious matter, for the reason that constant spraying is needed, irrespective of variety, in order to check downy mildew.

Out in the western and southern districts, where the climate is not so moist, there is a greater range in selection of varieties. At the same time there is no need to have a large number. The main object is to have vines

adapted to the systems of training which it is proposed to adopt. For instance, if ordinary bush vines are desired, such varieties as Muscat Hamburg, Muscat Gardo Blanco, Doradillo, Red Prince, Flome Tokay, Waltham Cross, and Frontignac form a good selection. The same varieties may be trained on simple trellises as spaliers and cordons.

When it is desired to carry out a more elaborate system of training, such, for instance, as over a pergola, or to shade the side of a house, care should be exercised in the selection of suitable varieties. Two of the best vines for this purpose are the Zante Currant and the White Crystal, because of their strong growth. In addition to these, other useful varieties are Sweet Water, Muscat Hamburg, Grand Turk, and Waltham Cross. All these latter varieties are strong growers when given fair treatment, and when assisted with liberal watering they will effectively cover an extensive area. Unless one has the means of promoting vigorous growth, it is a mistake to undertake too ambitious a scheme of training. It is far better to restrict the vines to one of the simpler forms, such as the bush cordon, or spalier. These have been fully explained in previous articles, so there is no occasion to make further reference to these systems.

Covering a pergola is a matter which requires a good deal of planning and patient construction. Probably the most common mistake made in this connection is to cover in the sides so as to exclude light, the result of which is to prevent the proper development and maturing of the fruit. The best plan is to build the whole of the fruit-bearing arms overhead, leaving a clean stem up to the height of the frame work. In this way, the fruit hangs down beneath the foliage, at the same time receiving ample air and light. A fringe of foliage will hang down over the side, forming a certain amount of shade and taking off the bareness from the sides of the structure.

Take, for instance, a structure intended to shade the side of a house. According to circumstances, the vines will be planted from 10 feet to 12 feet from the wall. Several posts about 8 feet apart and 7 feet out of the ground will be placed in line and connected with a stout top rail. The posts should be of 4 inches square hardwood, and the top rail 4 inches x 2 inches softwood, morticed on to and bolted to the tops of the posts. A wall plate will be needed just above the tops of the windows, say, 8 feet to 9 feet from the ground. Principals of 4 inches x 2 inches softwood and spaced 6 feet apart will connect the post line and the wall. Rafters of 3 inches x 2 inches softwood cross these at intervals of 3 feet to complete the structure. The vines will be planted 6 feet apart to correspond with the positions of the principals.

Formation.

The stems will be 7 feet high, that is, the height of the posts, before any secondary arms are formed. This will necessitate considerable vigour, because a strong shoot must be secured to form the stem. If need be, it can be built up in sections, encouraging the topmost cane and tying it carefully to prevent breakage. It is a good plan to have a light rod from the base of

the vine to the rail, up which the stem is trained for the first few years. As the stem becomes long enough, it is carried over the top of the structure to form the main arm.

From this point the formation resembles that laid down for cordon systems. The arm is trained from year to year until it reaches the wall. Spurs to form the secondary arms are spaced about 8 inches to 9 inches apart, and alternately on either side of the main arm. As the growth develops during the summer it spreads on either side of the arm, forming a thick canopy of foliage over the whole of the top of the structure. The fruit bunches, as they form, hang down beneath this foliage, and in a good trellis present a very handsome appearance when ripe. The growth from the lower secondary arms will hang down over the side like a curtain.

The same plan may be followed out in covering any structure. The main point to be observed is the training of secondary arms as near as possible on horizontal lines. One advantage of a definitely planned structure is that it can easily be protected from birds by covering it with small mesh wire-netting or with bird nets.

Annual Pruning.

During the growing period, the distribution of the foliage can be assisted by training the young canes and tying them in such a position as will distribute the growth. This operation also prevents a good deal of breakage by wind in the early portion of the season, while later on it means a better distribution of the fruit bunches.

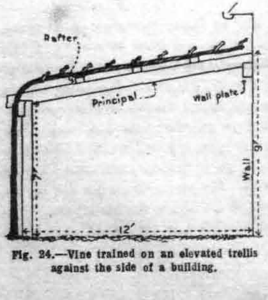

Fig. 24.—Vine trained on an elevated trellis against the side of a building.

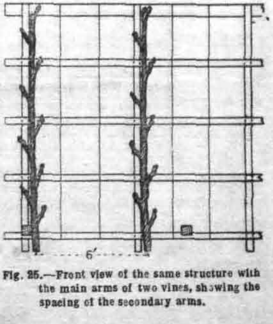

Fig. 25.—Front view of the same structure with the main arms of two vines, showing the spacing of the secondary arms.

The winter pruning is simple when the vines are formed. It consists in reducing each arm to one spur of two buds and removing all water shoots. Fig. 24 illustrates the elevation of the trellis, showing one vine fully developed. Fig. 25 shows a portion of the plan with the main arms of two vines. The system can be extended to any number.

It is sometimes desired to train vines upon a verandah, in which case the same principle can be carried out. The stem is trained to nearly the height of the verandah posts, and the arms are then built up as spaliers or cordons, the annual growth hanging down curtain-like.

When it is specially desired to enclose the sides of a structure, the object can be achieved by training cordons at varying heights upon supporting wires.

Another case may arise where the vines are planted on either side of a pathway covered by a trellis. In order to shade such a structure the vines may be trained as cordons alternately from either side.

Vines are sometimes grown against a wall which it is desired to cover up. In the first place it will be necessary to erect some supporting timber structure, with wires at varying heights. Upon these wires the arms of the vines will be trained in such a manner as to cover the wall completely.